PRESERVATION OF A NEBULAR *mg*- ^{17}O CORRELATION DURING PARTIAL MELTING OF UREILITES.

Cyrena Anne Goodrich, RR1, Box 98, Chester, VT 05143.

Ureilites are a class of 50+ achondrites that display a bewildering mix of igneous and primitive characteristics. There appears to be a movement [e.g. 1,2] to classify ureilites as "primitive achondrites", grouping them with acapulcoites, lodranites, winonaites, and silicates in IAB-IIICD irons. These are meteorites that are close to chondritic in bulk composition but have igneous textures, and thus appear to be transitional between chondrites and achondrites. In the opinion of this author, ureilites should not be classified as primitive achondrites because they are not close to chondritic in bulk composition, and doing so obscures the fact that no model has yet successfully reconciled their igneous and primitive characteristics. This work addresses the apparent incompatibility of the mineralogy and lithophile element chemistry of ureilites with their oxygen isotopic characteristics.

Two aspects of the oxygen isotopic characteristics of ureilites present problems:

1) Ureilite mineralogy, textures, mineral chemistry, and bulk lithophile element chemistry indicate that these rocks have experienced a significant amount of partial melting, if their precursor material was chondritic, and were equilibrated at temperatures as high as 1250°C (evidence summarized in [3]). However, oxygen isotopic compositions of ureilites plot along the slope-0.94 mixing line defined by CAI [4], indicating that they have not equilibrated oxygen isotopes with one another. These features can be reconciled if each ureilite (or perhaps 2-3 ureilites) formed in an isolated km+-sized zone on an isotopically heterogeneous ureilite parent body (UPB) [5]. However, this would imply that Earth has received 1-2 samples of each of 30-50 isolated zones of the UPB. Important questions remain as to whether this is plausible and under what dynamic conditions. Does it require 30-50 distinct impacts, or one large (planet-shattering?) impact?

2) Fe/Mn-Fe/Mg and Fe/Cr-Fe/Mg trends among ureilites indicate that ureilites formed by various degrees of reduction of common material. Since ureilites contain primary carbon [6,7] it is natural to assume that carbon was the reducing agent and that *mg* ratios of olivine and pyroxene were controlled by pressure (depth) in the UPB [8]). On the other hand, ureilites show a correlation of *mg* ratio and ^{17}O [1,4]. Such correlations are otherwise observed only in very primitive materials such as among chondrules and their rims in Allende, and among the H-L-LL ordinary chondrite groups (Fig. 1). These features could be reconciled if all ureilites formed at p > 100 b (~100 km depth), so that carbon reactions were not sufficiently reducing to alter nebular *mg* ratios [9,10]. However, the question still remains whether a nebular *mg*- ^{17}O correlation could survive the partial melting necessary to produce ureilites from chondritic material. Goodrich [3] assumed that it could not, because ureilites would not be expected to have all undergone precisely the same degree of melting. Upon further consideration it seemed that this assumption needed to be tested. Results of model calculations are presented here.

Model: It is assumed that prior to melting ureilite source materials displayed a perfect *mg*- ^{17}O correlation offset from that presently observed (Fig. 2). "Chondritic" bulk compositions were chosen to provide the required range in starting *mg* (71-92). Using an equilibrium partial melting program written and kindly provided by J. Longhi, these compositions were melted random amounts in the range between that necessary to exhaust plagioclase and 30% (an approximate upper limit for the degree of melting required by ureilite REE patterns). The resulting relation between *mg* (Fo content of equilibrium olivine in residue) and ^{17}O among these compositions was then compared to the original correlation and to the observed *mg*- ^{17}O data for ureilites (Fig. 3 and 4).

Results: 1) For the chondritic compositions investigated, plagioclase was exhausted at 11-18% melting. 2) During 30% partial melting the Fo content of equilibrium olivine in the solid changes by *at most* ~7 units. 3) Known bulk chondritic compositions do not cover the range of *mg* ratios required for ureilite precursor material, and in particular none is sufficiently magnesian to produce the more magnesian ureilites (those with Fo greater than ~88). 4) After partial melting to random degrees in the range 11-30%, an originally perfect *mg*- ^{17}O correlation is still quite good (r = 0.90-0.99). The calculated data resemble those observed for ureilites, but show *less* scatter, contrary to the expectation of the author.

PARTIAL MELTING OF UREILITES: C.A. Goodrich

Conclusions: The results presented here remove one of the obstacles to reconciling the oxygen isotopic and mineralogical-textural-chemical data for ureilites: it appears that a nebular *mg*- ^{17}O correlation could survive the partial melting required to produce ureilites from chondritic material. However, they leave several questions: 1) Is there (or was there ever) chondritic material that we have not yet sampled which is sufficiently magnesian to produce the more magnesian ureilites?   The possibility that there is not suggests that we reconsider the theory that carbon-controlled reduction on the UPB is responsible for the observed range in Fo in ureilites.   2) How were nebular *mg*- ^{17}O correlations established on 3 quite different scales: that of individual chondrules; that of meteorites (=km$^+$-sized zones on a single parent body?); and that of meteorite groups (=parent bodies?)? 3) Why have we sampled so many different *mg*- ^{17}O zones from the UPB instead of just one or two?

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